Nodal vs. Element Solutions in ANSYS APDL

Computer Homework 7

MEMS1047, Finite Element Analysis

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Introduction:

The aim of this homework was to perform a two-dimensional finite element analysis and to compare nodal and element stress plots for the beam model provided in Figure 1.

Figure 1 – Beam Model

We will use E = 29e06 psi, Poisson's Ratio, υ = 0.25, and unit thickness. For this analysis, we would like to use six or elements over the height (vertical direction) and elements that are close to being square. The element type used for this problem is PLANE182 (4 node quadrilateral element). There is a uniform load of P = 20 lbs placed on the tip at the free-end of the beam.

Problem Statement:

Given the loading condition provided in Figure 1, we would like to make a contour plot of σ_{xx} based on nodal and element stress plots and compare the maximum values for each plot. Additionally, we will compare nodal and element stress plots for σ_{xy}, and comment on the differences in results. We note here that we expect the nodal and element solutions to differ in magnitude.

Results:

Nodal and element solutions for σ_{xx} are shown in Figures 2 and 3, respectively. From Figure 2, we find that the maximum nodal axial stress is

$$\sigma_{xx}^{max} = 891.322\ psi \tag{1}$$

And, from Figure 3, we have that the maximum element axial stress is

$$\sigma_{xx}^{max} = 891.322\ psi \tag{2}$$

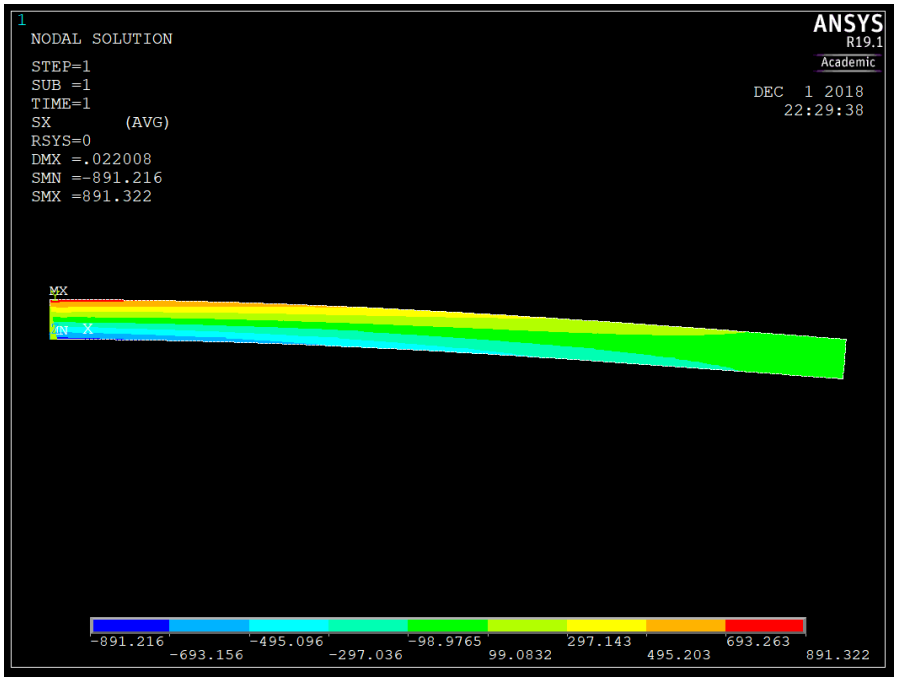

Figure 2 – Nodal Solution for σ_{xx}

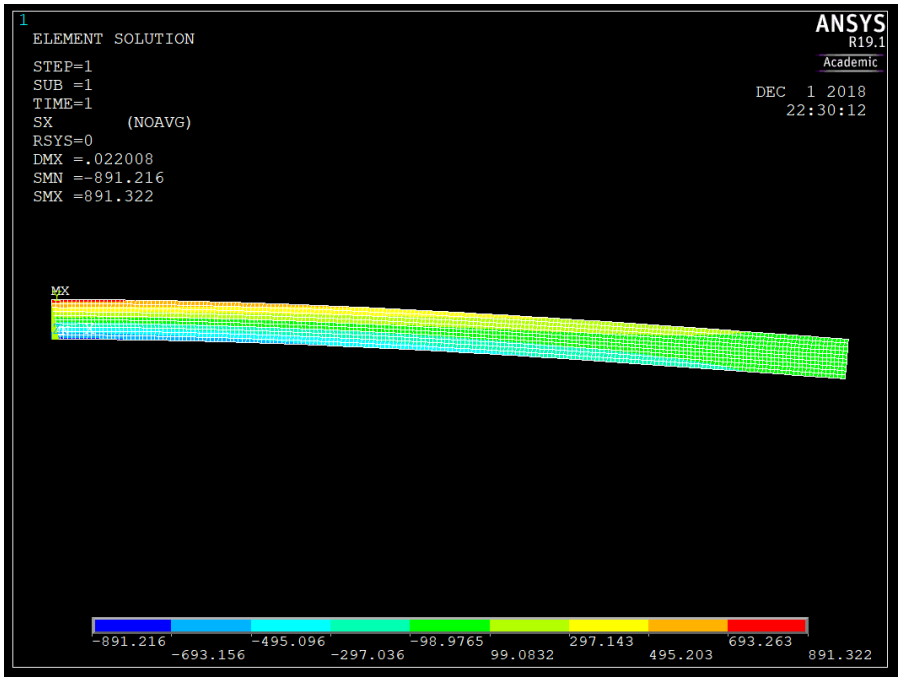

Figure 3 – Element Solution for σ_{xx}

Nodal and element solutions for σ_{xy} are shown in Figures 4 and 5, respectively.

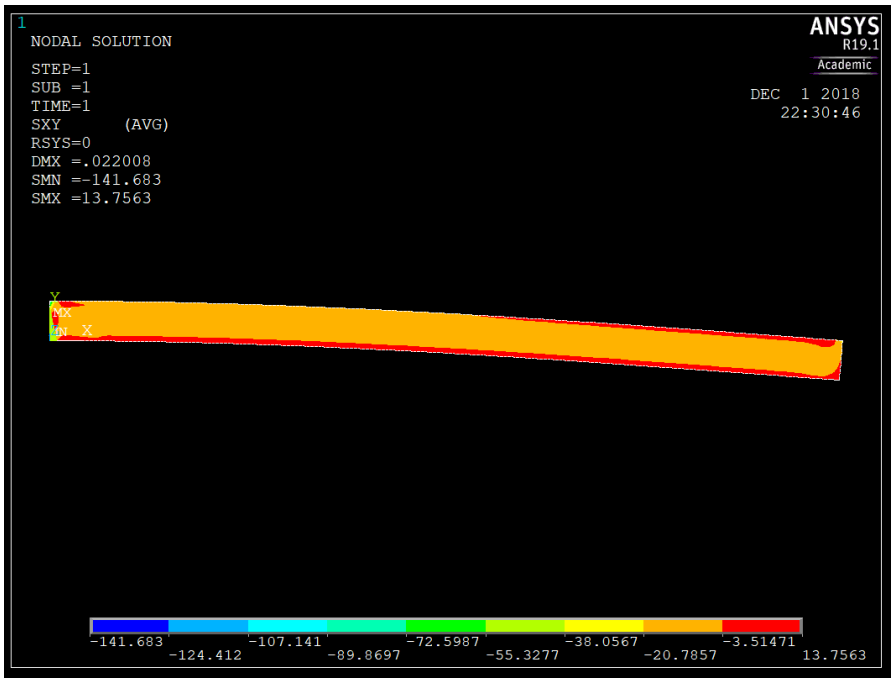

Figure 4 – Nodal Solution for σ_{xy}

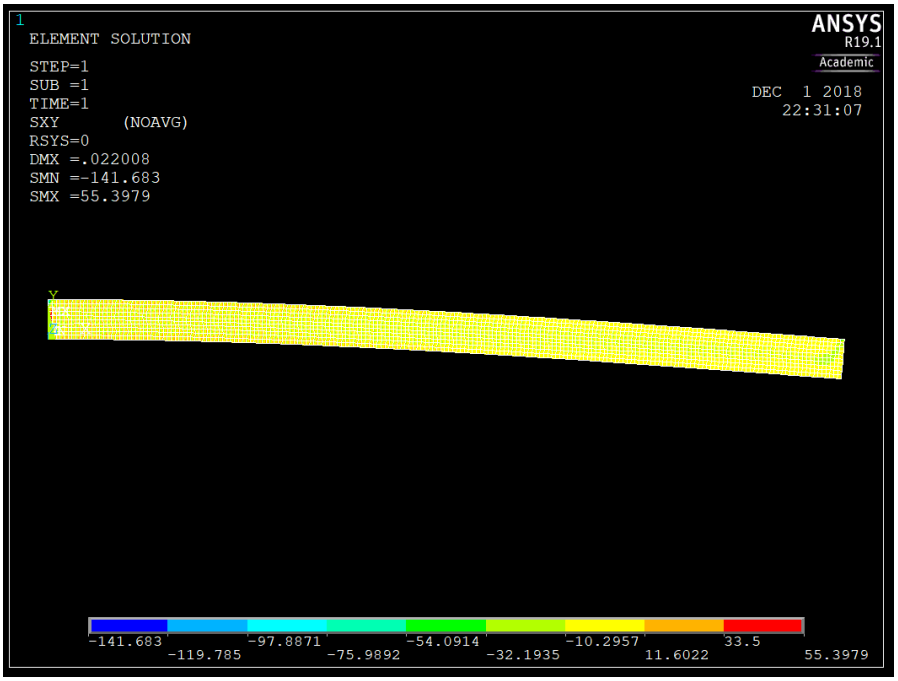

Figure 5 – Element Solution for σ_{xy}

From Figure 4, we find that the maximum nodal shear stress is

$$\sigma_{xy}^{max} = 13.7563\ psi \tag{3}$$

Likewise, from Figure 5, we find that the maximum element shear stress is

$$\sigma_{xy}^{max} = 55.3979\ psi \tag{4}$$

Discussion:

From the results given in (1) and (2), we note that the maximum axial stress is the same for both nodal and element solutions. However, when examining the maximum shear stress given in (3) and (4), we note a discrepancy in the values. In particular, we note that the maximum element shear stress is about four times that of the maximum nodal shear stress. We explain this phenomenon by the fact that the element stress is calculated by taking nodal averages over the element, which may cause it to achieve a higher or lower value of maximum stress.